

United States
Department of
Agriculture

Soil
Conservation
Service



Soil Mechanics Level I

Module 3 - USDA Textural Soil Classification

Study Guide

SOIL MECHANICS LEVEL I
MODULE 3
USDA TEXTURAL CLASSIFICATION
STUDY GUIDE

National Employee Development Staff
Soil Conservation Service
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SOIL MECHANICS - LEVEL I
MODULES 3
USDA TEXTURAL CLASSIFICATION
STUDY GUIDE

INTRODUCTION

This training module on the USDA Textural Classification is one of 3 modules of the Soil Mechanics Level I course. The modules in this course are:

1. Unified Soil Classification System
2. AASHTO (American Association of State Highway and Transportation Officials)
3. USDA Textural Soil Classification

INSTRUCTION

The procedure of a slide/audio cassette presentation is to project a picture while playing the accompanying cassette. The narration corresponds with what you see on the screen. During the presentation you will be asked to STOP the machine and do activities in your Study Guide. These activities offer a variety of learning experiences and give you feedback on your ability to accomplish the related module objectives.

Module 3 has one major section with specific objectives that need to be accomplished. The ability to review and study your material at your desk, while traveling, or in an easy chair is what makes a self-paced training package so beneficial. If you have difficulty in a specific area, study, re-study, and, if necessary, get someone to help you. DO NOT continue until you can complete each activity.

You should complete each part of this module as follows:

1. Read the objectives.
2. Run the slide/audio cassette, stopping it when you need to work in the Study Guide.
3. Study and review all references.

If you have difficulty in a specific area, contact your State Soils Staff, through your supervisor, for assistance.

CONTENTS

- 1 Slide tray
- 1 Audio cassette
- 1 Study Guide

ACTIVITY 1 - Objectives

1. List and explain the definitions of the three soil separates as used in the twelve major soil classes of the USDA Textural Classification System.
2. Correctly classify soils into one of the twelve major USDA textural classes using the textural triangle and laboratory data.
3. Explain the relationship of consistence and texture for dry and wet soils.
4. Correctly classify each soil sample into one of the twelve major USDA textural classes using a flow chart, consistence, and other field tests that you perform on the these samples.

ACTIVITY 2 - Size Criteria for Soil Separates in the USDA Textural Classification System

Soil separates are the individual size-groups of mineral particles. The scheme used in the U.S. Department of Agriculture is shown below. Mechanical analyses of soils in soil survey laboratories of the U.S. Department of Agriculture are reported using this system.

Size Limits of USDA Soil Separates

<u>Name of separate</u>	<u>Diameter range (millimeters)</u>
Sand	2.0-0.05
Silt	0.05-0.002
Clay	less than 0.002

The sand separate is subdivided into very coarse sand, coarse sand, medium sand, fine sand, and very fine sand. The size ranges for these subdivisions are given below:

<u>Subdivisions</u>	<u>Diameter range (millimeters)</u>
Very coarse sand	2.0-1.0
Coarse sand	1.0-0.5
Medium sand	0.5-0.25
Fine sand	0.25-0.10
Very fine sand	0.10-0.05

Relative sizes of sand, silt, and clay are shown in figure 1 on the next page.

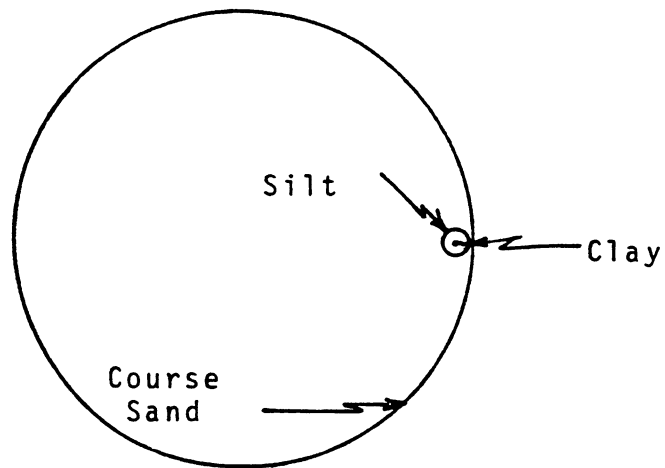


Figure 1. Relative sizes of sand, silt, and clay separates in the USDA Textural Classification System. Even though the three kinds of soil particles have been enlarged about 60 times, the clay particle can barely be seen.

Table 1 - Comparison of Particle Sizes

SOIL MECHANICS LABORATORY FORT WORTH, TEXAS					PARTICLE SIZES									
U.S. STANDARD SIEVE SIZE					GRAIN SIZE IN MILLIMETERS									
System														
Colloids*	Clay	Silt	Fine Sand	Coarse Sand	Fine Gravel	Medium Gravel	Coarse Gravel	Boulders	A A S H T O					
Clay	Silt		Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse Sand	Cobbles	U S D A					
Clay	Silt		Fine Sand	Coarse Sand	Gravel				F A A					
Clay**	Silt**		Fine Sand	Medium Sand	Coarse Sand	Fine Gravel	Coarse Gravel	Cobbles	U S C S					

* Colloids included in clay fraction in test reports.

** The LL and PI of "Silt" plot below the "A"-line on the Plasticity Chart and the LL and PI of "Clay" plot above the "A"-line, or in the hatched zone.

ACTIVITY 4 - USDA textural classification chart

In the USDA textural triangle below, the corners represent 100 percent sand, silt, or clay, as indicated. (Gravel and organic soils are not included.) The triangle is divided into 10-percent portions of clay, silt, and sand. Heavy lines show the divisions between 12 basic soil textural classes. If the percentage for any two of the soil separates are known, the correct textural class can be determined. However, the summation of the three percentages must total 100 percent.

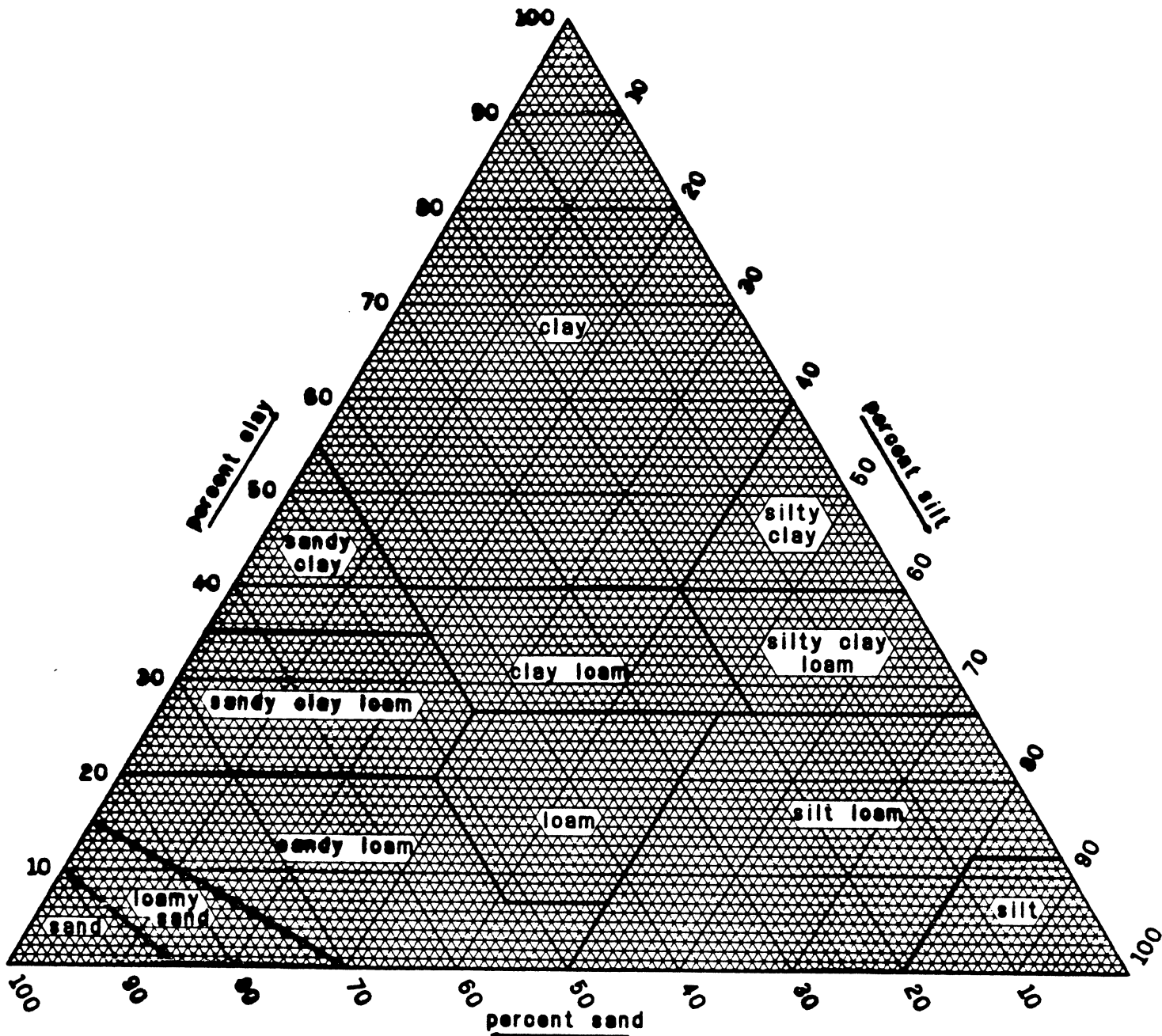


Figure 2. USDA Textural Triangle

ACTIVITY 5 - Behavioral Properties of USDA Textural Classes

Some of the most important properties that can be used to differentiate a soil's behavior in the USDA Textural Classification System are defined and discussed below:

Specific Surface - Specific surface is the surface area of a soil particle per unit of mass. For instance, sands are the largest soil separate but have a relative high unit mass. Therefore, they have small specific surfaces. Clays, although very small particles, have extremely low mass and large specific surfaces. Refer to figure 3 in this Activity for a sketch of specific surfaces. Small, intermediate, and large are the terms used to describe a soil particle's specific surface.

Plasticity - Plasticity is the property of a soil that enables it to change shape continuously under the influence of an applied stress and to retain that shape on removal of the stress.

This definition differs from that used by engineers as you learned in Module 1.

The descriptive terms used to describe plasticity are nonplastic, slightly plastic, plastic, and very plastic. Plasticity depends on the amount and type of clay present and the water content.

Stickiness - Stickiness is the adhesion exhibited by a soil and water mixture to other objects. It depends on the amount and type of clay and the water content.

Descriptive terms used are nonsticky, slightly sticky, sticky, and very sticky.

Particle Composition - Composition is the material that constitutes a soil's make up. It may be parent rock material such as limestone, a primary mineral such as quartz, or a clay mineral such as montmorillonite. It may also be a combination of any all of these.

Visibility - Visibility is the ease with which an observer can actually see the individual particles of a soil. The degrees of description used are:

- (1) can be seen with naked eye
- (2) can be seen with the aid of a hand lens
- (3) can only be seen with an electron microscope.

Shape - Shape is the form of the individual soil particle. The terms normally used to describe particle shape are round, irregular, and flat, figure 4.

ACTIVITY 5 - BEHAVIORAL PROPERTIES OF USDA TEXTURAL CLASSES CONTD.

Water Absorption and Retention - Water absorption and retention is the capability of a soil to readily take on and retain water. These properties are generally dependent on the amount and type of clay present in the soil. Terms used to describe these properties are low, moderate, and high.

Reactions of sand, silt, and clay to these behavioral properties is shown in table 2 on the next page.

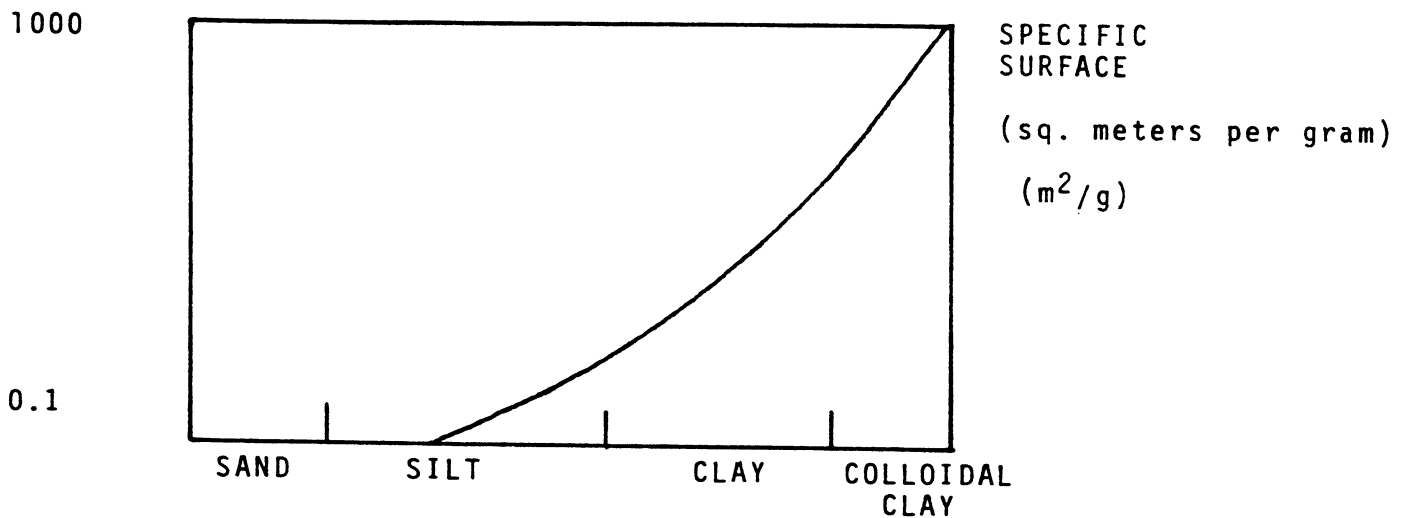


Figure 3. Comparison of specific surfaces for sand, silt, and clay

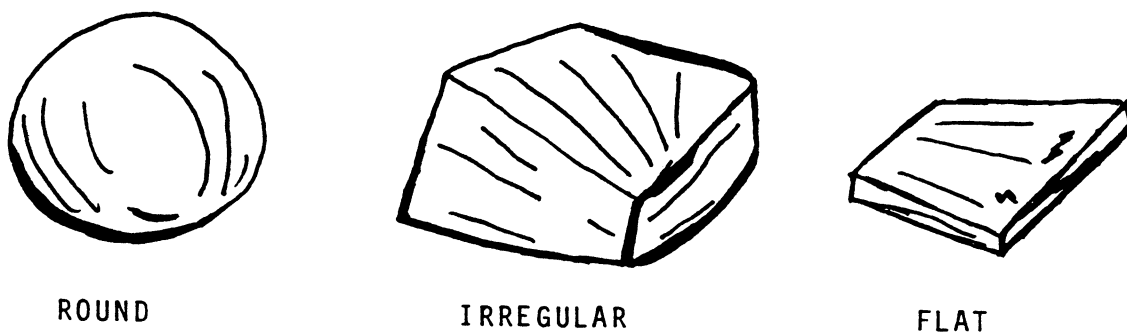


Figure 4. Particle shapes

Table 2. - A comparison of the reactions of the three soil separates to certain behavioral properties

PROPERTY	SAND	SOIL SEPARATE SILT	CLAY
Specific surface	Small	Intermediate	Large
Plasticity	Nonplastic	Nonplastic to slightly plastic	Plastic to very plastic
Stickiness	Nonsticky	Nonsticky to slightly sticky	Sticky to very sticky
Particle composition Minerals	Rock fragments and	Primary primary materials	Clay minerals
Visibility of individual particles	Eye	Large ones can be seen with a hand lens	Electron microscope
Shape	Round	Irregular	Flat
Ability to absorb and retain water	Low	Low to moderate	High
Size	2.0 - 0.05 mm	0.05 - 0.002 mm	less than 0.002 mm

ACTIVITY 6 - Size and Percentage Criteria for the Twelve Major USDA
Textural Classes

Major Textural Classes

The 12 major soil textural classes are based on the relative percentage of sand, silt, and clay in the soil sample or material. The definitive criteria for each of these classes are:

SAND

- A. Must contain 85 percent or more of sand, and
- B. The percentage of silt plus 1.5 times the percentage of clay shall not exceed 15.

LOAMY SAND

- A. Upper limit
 - 1. Must contain 85 to 90 percent of sand, and
 - 2. The percentage of silt plus 1.5 times the percentage of clay is not less than 15.
- B. Lower limit
 - 1. Must contain 70 to 85 percent sand, and
 - 2. The percentage of silt plus twice the percentage of clay does not exceed 30.

SANDY LOAM

- A. Contains 20 percent or less clay, and
- B. The percentage of silt plus twice the percentage of clay exceeds 30 and has 52 percent or more sand, or
- C. Contains less than 7 percent clay, less than 50 percent silt, and between 43 and 52 percent sand.

LOAM

Contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand.

SILT LOAM

- A. Contains 50 percent or more silt and 12 to 27 percent clay, or
- B. Contains 50 to 80 percent silt and less than 12 percent clay

SILT

Contains 80 percent or more silt and less than 12 percent clay.

SANDY CLAY LOAM

Contains 20 to 35 percent clay, less than 28 percent silt, and 45 percent or more sand.

CLAY LOAM

Contains 27 to 40 percent clay and 20 to 45 percent sand.

SILTY CLAY LOAM

Contains 27 to 40 percent or more clay and less than 20 percent or more sand.

SANDY CLAY

Contains 35 percent or more clay and 45 percent or more sand.

SILTY CLAY

Contains 40 percent or more clay and 40 percent or more silt.

CLAY

Contains 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

SUBDIVISIONS OF SAND

The sand separate can be subdivided on the basis of the percentages of specific sizes. These subdivisions are coarse sand, sand, fine sand, and very fine sand.

COARSE SAND

Contain 25 percent or more of very coarse and coarse sand and less than 50 percent of any other one subdivision of sand.

SAND

Contain 25 percent or more of very coarse, coarse, and medium sand and less than 50 percent fine or very fine sand.

FINE SAND

Contain 50 percent or more fine sand; or less than 25 percent very coarse, coarse, and medium sand and less than 50 percent very fine sand.

VERY FINE SAND

Contain 50 percent or more very fine sand.

SUBDIVISIONS OF LOAMY SAND CLASS BASED ON PREDOMINANT SAND SIZE

LOAMY COARSE SAND

Contains 25 percent or more of very coarse and coarse sand and less than 50 percent of any other one subdivision of sand.

LOAMY SAND

Contains 25 percent or more of very coarse, coarse, and medium sand and less than 50 percent fine or very fine sand.

LOAMY FINE SAND

Contains 50 percent or more fine sand; or less than 25 percent very coarse, coarse, and medium sand and less than 50 percent very fine sand.

LOAMY VERY FINE SAND

Contains 50 percent or more of very fine sand.

SUBDIVISIONS OF SANDY LOAM CLASS BASED ON PREDOMINANT SAND SIZE

COARSE SANDY LOAM

Contains 25 percent or more very coarse and coarse sand and less than 50 percent of any other one subdivision of sand.

SANDY LOAM

Contains 30 percent or more of very coarse, coarse, and medium sand, but less than 25 percent of very coarse sand, and less than 30 percent of very fine or fine sand.

FINE SANDY LOAM

Contains 30 percent or more fine sand and less than 30 percent of very fine sand or between 15 and 30 percent very coarse, coarse, and medium sand.

VERY FINE SANDY LOAM

Contains 30 percent or more very fine sand; or more than 40 percent fine and very fine sand; at least half of which is very fine sand, and less than 15 percent very coarse, coarse, and medium sand.

ACTIVITY 7: Problem - Plot the data given below on the USDA textural triangle and determine correct textural class of each example soil.

Soil sample	% Sand	% Clay	% Silt	Textural class
1	10	45	45	
2	70	10	20	
3	40	35	25	
4	55	40	5	
5	90	2	8	
6	8	2	90	
7	20	60	20	
8	60	22	18	
9	80	5	15	
10	23	68	9	

Check your results with the answers on the next page. If you missed any of the examples, you should review Activities 2 through 6.

Answers to Activity 7

1. silty clay
2. sandy loam
3. clay loam
4. sandy clay
5. sand
6. silt
7. clay
8. sandy clay loam
9. loamy sand
10. clay

ACTIVITY 8 - SOIL CONSISTENCE

Consistence is the "feel" of the soil and the ease with which a lump can be crushed by the fingers. It is dependent upon particle size, water content, clay mineralogy, and the presence or absence of cementing agents such as calcium carbonate, silica, salts, or iron and aluminum oxides. Consistence is evaluated at two water contents (dry and wet).

The consistence terms used for this module are:

Consistence when dry: Consistence of soil materials when air dry is characterized by rigidity, brittleness and maximum resistance to pressure. It is the tendency to crush to a powder or to fragments with the inability of crushed material to cohere again when pressed together. The procedure is to select an air dry clod and break between the thumb and forefinger or in the hand. Evaluate on the basis of the following:

1. Loose: Noncoherent (will not stick together - single grained)
2. Soft: Soil mass is weakly coherent and fragile; breaks to a powder or individual grains under very slight pressure.
3. Slightly hard: Weakly resistant to pressure; can be broken between thumb and forefinger.
4. Hard: Moderately resistant to pressure; can be broken in the hand without difficulty but is barely breakable between thumb and forefinger.
5. Very hard: Very resistant to pressure; can be broken in the hand only with difficulty; not breakable between thumb and forefinger.
6. Extremely hard: Extremely resistant to pressure; cannot be broken in the hands.

Consistence when wet: Consistence when wet is determined at or slightly above field capacity (water content at 1/3 atmospheres pressure) or slightly above the plastic limit. Stickiness and plasticity are evaluated at a soil's wet consistence.

Stickiness is the quality of adhesion to other objects. For field determination of stickiness, soil material is pressed between thumb and forefinger, and its adherence is noted using the guidelines below:

1. Nonsticky: After release of pressure, practically no soil material adheres to thumb or forefinger.
2. Slightly sticky: After pressure, soil material adheres to thumb and forefinger but comes off one or the other rather cleanly. It is not appreciably stretched when the digits are separated.
3. Sticky: After pressure soil material adheres to both thumb and forefinger and tends to stretch somewhat and pull apart rather than pulling free from either digit.
4. Very Sticky: After pressure, soil material adheres strongly both thumb and forefinger and is decidedly stretched when separated.

ACTIVITY 8 - SOIL CONSISTENCE CONTD.

Plasticity is the property of a soil that enables it to change shape continuously under the influence of an applied stress, and to retain the impressed shape on removal of that stress. For field determination of plasticity, roll the soil material between thumb and forefinger, and observe whether or not a wire or thin ribbon of soil can be formed. Evaluate on the basis of the following guidelines:

1. Nonplastic: No wire or ribbon is formed.
2. Slightly plastic: Wire or ribbon formable but soil mass easily deformable.
3. Plastic: Wire or ribbon formable and moderate pressure required for deformation of the soil mass.
4. Very plastic: Wire or ribbon formable and much pressure required for deformation of the soil mass.

ACTIVITY 9 - Additional Field Tests for Estimating Textural Classes

Molded Ball is the property of a soil that enables it to be molded into a spheroid under the influence of an applied stress and to retain that shape while being deformed. For field determination, roll the soil material in the palms to form a ball. Observe the ball's resistance to breakage when stress is applied by a finger.

Observations should be noted using the following terms:

1. None - A ball cannot be formed.
2. Very weak - Ball crumbles when touched by a finger.
3. Fragile - Ball retains its shape when touched gently.
4. Strong - Ball retains its shape when touched and handled freely.
5. Very strong - Can be formed into any shape and will retain that shape even under rough handling and high finger pressure.

Ribboning is the property of a soil that allows the development of a flat ribbon under the influence of an applied stress and will retain that shape. For field determination, extrude the soil between thumb and forefinger until the ribbon formed breaks, then measure the ribbon. Definitions are expressed in the length of ribbon formed.

1. None - No ribbon can be formed.
2. Slight - Less than 2.5 cm.
3. Medium - Between 2.5 and 5 cm.
4. High - Greater than 5 cm.

Grittiness is the abrasive action felt by the thumb and forefinger or palm of the hand when kneading soils containing an appreciable amount of sand. For field determination rub the soil between the thumb and forefinger or palm of hand. Terms commonly used to describe grittiness are:

1. None - No individual grains are felt. No abrasive feeling.
2. Some gritty - Some grains can be felt.
3. Gritty - Abrasive feeling is easily felt.
4. Very gritty - Most of soil is individual grains that can easily seen and felt.

Smoothness is a quality exhibited by some soils when kneading between the thumb and forefinger or palm of the hand. Soils are smoothest when they contain few, if any, sand grains. For field determination, rub the soil between the thumb and forefinger or palm of the hand. Terms commonly used to describe smoothness are:

1. Somewhat smooth - Smooth feeling but some grittiness felt.
2. Smooth - Very little grittiness felt.
3. Very smooth - No grittiness felt.

Note: Sand, loamy sand, sandy loam, sandy clay loam, and sandy clay are not normally evaluated using the smoothness test because of their sand content.

Molded ball, ribboning, grittiness, and smoothness tests are run at a wet consistence.

ACTIVITY 10 - Guidelines for Estimating Textural Classes

The determination of soil texture class of the less than 2 mm material is made in the field mainly by feeling the soil with fingers. Sometimes the soil is examined under a hand lens. The soil must be well moistened and rubbed vigorously between the fingers for a proper determination of textural class. This requires skill and experience. Good accuracy can be obtained if frequent checks against laboratory results are made. Many SCS offices collect reference samples of known particle sizes for this purpose. The particles coarser than 2 mm are determined by estimating the proportion of the soil volume that they occupy, or their amounts can be determined by sieving.

The soil properties usually evaluated in the process of estimating the percent sand, silt, and clay are provided in table 3. The adjectives listed are commonly noted when distinguishing the various textural classes and are defined in Activities 8 and 9.

The flow chart diagram, figure 5, provides the instructional steps for estimating soil texture by feel. Both the table and chart are used when determining soil textures in the field. Their use is intended as a general guide since some soils may react differently to kneading or handling from one locale to another.

Note that figure 5 contains only eleven textural classes. Silt is not included. There are few soils in nature that classify as a silt. Usually, silts can only be distinguished from silt loams by using laboratory data.

GUIDE FOR ESTIMATING USDA TEXTURAL CLASSES

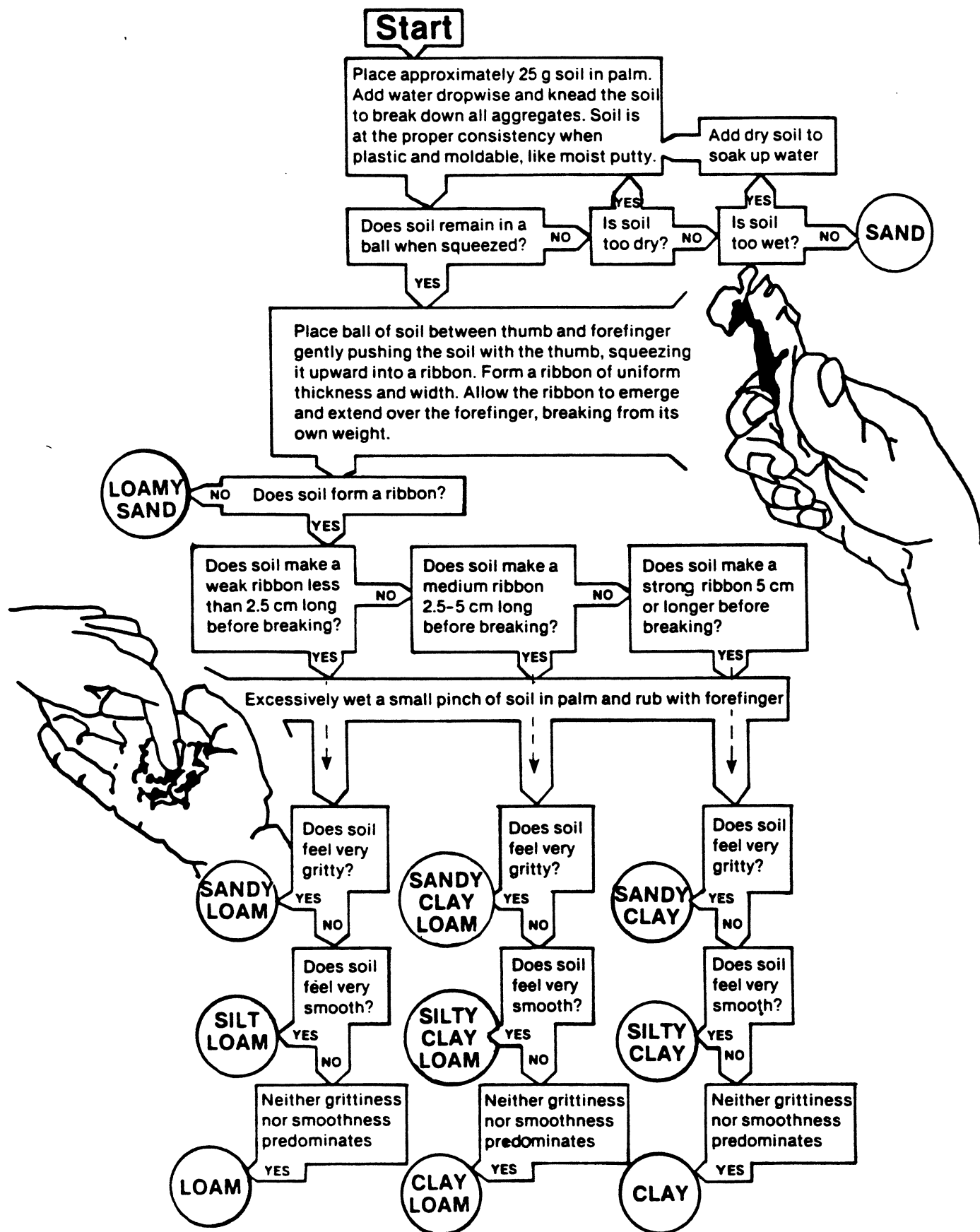
USDA TEXTURE CLASS	CONSISTENCE			OTHER TESTS EVALUATED AT A WET CONSISTENCE			
	DRY	WET		MOLDED BALL	RIBBONING ¹	GRITTIENESS	SMOOTHNESS ²
		STICKINESS	PLASTICITY				
SAND	Loose	Nonsticky	Nonplastic	None	None	Very gritty	---
LOAMY SAND	Soft	Nonsticky	Nonplastic	Very weak	None	Very gritty	---
SANDY LOAM	Soft ³ to slightly hard	Nonsticky to slight- ly sticky	Nonplastic to slight- ly plastic	Very weak to fragile	Slight	Gritty	---
SANDY CLAY LOAM	Slightly hard to hard	Sticky	Plastic	Strong	Medium	Gritty	---
SANDY CLAY	Hard to very hard	Very sticky	Very plastic	Very strong	High	Gritty	---
LOAM	Slightly hard to soft	Slightly sticky to nonsticky	Slightly plastic to nonplastic	Strong to fragile	Slight to none	Somewhat gritty	Somewhat smooth
CLAY LOAM	Hard	Sticky	Plastic	Strong	Medium	Somewhat gritty	Somewhat smooth to smooth
SILT LOAM	Slightly hard to soft	Slightly sticky to nonsticky	Slightly plastic to nonplastic	Strong	Slight	None	Very smooth to smooth
SILT	Soft to slightly hard	Nonsticky	Nonplastic	Fragile to very weak	Slight	None	Very smooth
SILTY CLAY LOAM	Hard	Sticky	Plastic	Strong	Medium	None	Very smooth
SILTY CLAY	Very hard	Very sticky	Very plastic	Very strong	High	None	Very smooth
CLAY	Very hard to extreme- ly hard	Very sticky	Very plastic	Very strong	High	None	Smooth to very smooth

¹ Length of ribbon guidelines are based on experience with soils containing significant amounts of montmorillonite clay. These guidelines should be adjusted locally to account for any difference in mineralogy. For instance, ribboning guidelines for soils having clays that are predominantly kaolinitic should be scaled downward.

² Smoothness is not evaluated for the textural classes of sand, loamy sand, sandy loam, sandy clay loam, and sandy clay because of their sand content.

³ The descriptive term listed first is generally the reaction most often observed.

ACTIVITY 10 - Figure 5 Flow diagram for estimating soil texture by feel



ACTIVITY 11 - Factors Affecting Field Estimates of USDA Textural Classes

Field estimates of textural classes are made by estimating the percentages by weight of sands, silt, and clay by feel and sight observations:

- A. Sand is gritty and the individual particles can be seen with the human eye.
- B. Silt is smooth or silky when wet and is generally nonsticky and nonplastic. Individual particles can be seen with a hand lens.
- C. Clay is also smooth when wet and exhibits stickiness and plasticity. As the clay content increases, stickiness, and plasticity increase.

Improved accuracy can be obtained with experience and by becoming familiar with the composition of local soils. Soil properties such as clay mineralogy, organic matter content, mica content, salt content, and others can and does influence field estimates of textural classes. A general discussion of these properties is provided.

1. Mineralogy:

- a. Very sticky and very plastic montmorillonitic clay soils appear to have a much higher clay content than sticky and plastic kaolinitic clay soils despite the clay content that is essentially the same.
- b. In some environments the clay is dominated by iron oxides. These may only be slightly sticky and slightly plastic when wet. They are usually identified as silt loam or possibly silty clay loam in the field because of their lack of stickiness and low plasticity though laboratory data suggests they should be clay.
- c. Volcanic ash soils high in amorphous materials just do not adequately disperse using conventional laboratory procedures. In these instances, the laboratory determined clay content is often low to very low, and in some instances meaningless. They can have high to very high liquid limits, but relatively low plasticity.
- d. Soil can contain materials that are 0.002 mm in size that are not clay minerals. Diatomaceous earth and lime (CaCO_3) are examples. Clays that are diatomaceous earth dominated are at best only slightly sticky and slightly plastic and feel like a silt or silt loam. Lime-dominated clays usually have stickiness and plasticity characteristics associated with the total clay content determined in the laboratory. Both total clay and carbonate-free clay are reported in some cases. The latter is determined by removing all carbonate clay. This makes the field estimate comparable to total clay reported by laboratory.

2. Organic matter:

Organic matter, in large amounts, lowers plasticity and dilutes the volume of mineral matter. This tends to cause an underestimation of clay, especially in fine and moderately fine textured soils. In sandy soils, however, large amounts of organic matter can result in an overestimation of clay.

ACTIVITY 11 - Factors Affecting Field Estimates of USDA Textural Classes
Contd.

3. Mica:

Large amounts of platy minerals of silt and sand sizes can appear somewhat finer because of a lubricating effect when wet. Water will collect on the platelet surfaces allowing soil particles to slide over one another when the soil is rubbed. The various micaeous minerals-- muscovite, biotite, vermiculte, and very fine shale chips are the most troublesome. A small weight difference of such grains can be pronounced because of their large surface area. The finer plates have

a greater influence on this lubricating effect.

4. Excess salts and sodium:

Soils containing abnormally large quantities (about 30% or more) of salts, particularly gypsum and sodium chloride, can appear somewhat sandy. This is due to crystallization of salt into sand-size particles. The amount of water used to wet the soil for determining wet consistency is not enough to dissolve all of the salts, hence they appear to be sand-sized particles. Soils containing excessive amounts of sodium and greater than 25 percent clay can appear to have a higher clay percentage because of the dispersive action of the sodium. This will result in an increase in stickiness and plasticity.

5. Others:

a. Very coarse sand derived from granite or parent rock is always a problem because its particle sizes is very close to 2 mm particles. Unless the soil is passed through a No.10 sieve such very coarse sand can be mistaken for fine gravel.

b. Sandy loams, loamy sands, and sands that have very low silt content are often misclassified one textural class finer. The low silt contained often accentuates the stickiness and plasticity effects of the clay in the soil.

c. Textural classes of silts and silt loams that have large amounts of fine silt can seem to have a higher clay content than the values determined in the laboratory.

d. Some soils may contain sand or even fine gravel sized particles of weathered parent rock such as granite, gneiss, schist, and shale. Field identification may suggest more sand and less clay than laboratory data because of the sample preparation procedures used in the laboratory.

ACTIVITY 12 - Quiz

1. Name the three soil separates used in the USDA Textural Classification System.
 - a.
 - b.
 - c.
2. Rock fragments are particles that have an equivalent diameter greater _____ mm.
3. How many basic textural classes are in the USDA textural triangle? _____
4. List these classes.
5. List the size criteria for
 - a. sand, less than _____ mm & greater than _____ mm
 - b. silt, less than _____ mm & greater than _____ mm
 - c. clay, less than _____ mm

Answer 6 thru 10 True or False

6. Clays generally consist of rounded particles _____.
7. Sands generally have large specific surfaces _____.
8. Silts generally have higher stickiness than sands _____.
9. Silts generally have higher plasticity than clays _____.
10. Clays have the ability to absorb large amounts of water but cannot retain it very long _____.
11. A soil has 15% clay, 50% sand, and 35% silt. What is its textural class on the textural triangle?
12. Define consistence.
13. Consistence is usually described at two standard moisture contents. Name them.
14. _____ and _____
Briefly describe how to use the flow chart to determine the textural class using field procedures.
15. Define grittiness.
16. Define plasticity.
17. What is the most important basis for using field procedures to determine a soil's textural class?
18. Name at least four factors affecting a soil's consistence.
 - a.
 - b.
 - c.
 - d.
19. Why was the USDA Textural Classification System developed?

ACTIVITY 12 - Solution to Quiz

1. a. sand
b. silt
c. clay
2. 2.0
3. 12
4. Sand, loamy sand, sandy loam, sandy clay loam, loam, silt loam, silt, sandy clay, clay loam, silty clay loam, silty clay, and clay.
5. a. 2.0 0.05
b. 0.05 0.002
c. 0.002
6. False. Flat particles
7. False.
8. True.
9. False.
10. False.
11. Loam.
12. Consistence is the "feel" of the soil and the ease with which a lump can be crushed by the fingers.
13. Dry and wet.
14. Begin at the top. Work your way down the chart performing each field test. The first block you arrive at is the correct class.
15. Grittiness is the abrasive action felt by the thumb and forefinger or palm of the hand when kneading a soil.
16. Plasticity is the ability to change shape continuously under the influence of an applied stress and retain that shape on removal of that stress.
17. Feel the soil with your finger!
18. a. Particle size
b. Water content
c. Clay mineralogy
d. Absence or presence of cementing agents.
19. For agronomic uses.

ACTIVITY 13 - USDA TEXTURAL CLASSIFICATION USING FIELD PROCEDURES

You will be given the 14 known and 14 unknown soil samples detailed in Activities 16 and 17 of Module 1 - Part C. Using the flow diagram (figure 5) in this module, develop expertise in using the chart to classify both known and unknown samples.

This activity will be done in conjunction with the facilitator-led one - day training session for Module 1 - Part C, Activities 16 and 17.

APPENDIX

SOIL MECHANICS LEVEL I
MODULE 3 -- USDA TEXTURAL
CLASSIFICATION
STORYBOARD

USDA TEXTURAL
CLASSIFICATION
System
(1)

This module explains the basics of the USDA Textural Classification System.

Purpose of
Classification
Systems
1. USCS...Engineering
2. AASHTO.Local Roads
and Streets
3. USDA Textural
Agronomical
(2)

In Module 1 you learned that the Unified Soil Classification System was developed for engineering uses. In Module 2 you learned that the AASHTO (pronounced ASH'-TOE) Classification System was developed to predict the load-carrying capability of soils for local streets and roads.

USDA Textural Data
may be used to convert
to USCS and the AASHTO
Classification Systems
(3)

The textural data used in this classification system may also be used to classify soils using the Unified and AASHTO classification Systems.

OBJECTIVES

1. List and explain the definitions of the three soil separates.
(4)

Upon completion of this module you will be able to meet the following objectives:

Objective 1. List and explain the definitions of the three soil separates as used in the twelve major textural classes of the USDA Textural Classification System.

OBJECTIVES

1. List and explain the definitions of the three soil separates.
2. Correctly classify soils into one of the 12 major textural classes using laboratory data and the textural triangle.
(5)

Objective 2. Correctly classify soils into one of the twelve USDA textural classes using the textural triangle and laboratory data.

OBJECTIVES

1. List and explain the definitions of the three soil separates.
2. Correctly classify soils into one of the 12 major textural classes using laboratory data and the textural triangle.
3. Explain the relationship of soil consistence and texture.

(6)

Objective 3. Explain the relationship of consistence and texture for dry and wet soils.

OBJECTIVES

1. List and explain the definitions of the three soil separates.
2. Correctly classify soils into one of the 12 major textural classes using laboratory data and the textural triangle.
3. Explain the relationship of soil consistence and texture.
4. Correctly classify samples using consistence, other field tests, and the flow chart.

(No. 4 Highlighted)

(7)

Objective 4. Correctly classify soil samples into one of the twelve USDA textural classes using the flow chart and results of consistence tests that you perform on these samples. These four objectives are also listed in your Study Guide.

BASIC DEFINITIONS

(8)

Let's take a look at some of the basic definitions necessary to classify a given soil into its correct USDA textural class.

SOIL TEXTURE

(9)

Soil texture is the relative proportion of the various particles that make up a soil mass.

THREE SIZE GROUPS

- (1) Sand
- (2) Silt
- (3) Clay

(10)

The USDA Textural Classification System recognizes three major particle size groups. They are sand, silt and clay.

Sand, silt, and clay have equivalent particle diameter less than 2.0 mm.

(11)

Clay, silt, and sand have an equivalent particle diameter less than 2.0 millimeters. Particles larger than 2.0 millimeters are discussed in a later module.

Soil Separates
(12)

Sand, silt, and clay are also called soil separates and each has a specified size range based on its diameter.

SANDS
...SMALLER THAN
2.0 mm, and
...LARGER THAN
0.05 mm.
(13)

Sand particles are smaller than 2.0 millimeters in diameter and larger than 0.05 millimeters.

SILTS
...SMALLER THAN
0.05mm, and
...LARGER THAN
0.002 mm.
(14)

Silt particles are smaller than 0.05 millimeters in diameter and larger than 0.002 mm.

CLAYS
...SMALLER THAN
0.002 mm.
(15)

Clay particles are smaller than 0.002 mm in diameter. Activity 2 in your Study Guide summarizes these size limits and compares the equivalent diameter of each soil separate. Press the pause button and review this activity before continuing.

SLIDE OF TABLE 1
of Activity 3
(16)

Table 1, Activity 3, of your Study Guide illustrates the size ranges of four different classification systems. The AASHTO, USCS, and the USDA Textural Classification Systems are all used in SCS work. Note the differences between the various systems. The USDA Textural Classification System is based solely on the percentages of sand, silt, and clay in a soil sample. Press the pause button to stop the tape and review the table.

USDA
TEXTURAL
TRIANGLE
(17)

The USDA textural triangle is used to determine the textural class of a soil when the percentages of sand, silt, and clay are known. Only the percentages of any two of these three soil separates are needed to use the textural triangle.

USDA TEXTURAL TRIANGLE (18)	Each of these soil separates is represented on a side of USDA Textural Triangle.
Activity 4 (19)	The textural triangle contains 12 basic classes. Each class has a specific range of percentages of sand, silt and clay. <u>Activity 4</u> in your Study Guide contains a copy of the USDA Textural Triangle. Press the pause button to stop the tape and locate this chart. You may want to clip this page as you will need to refer to it often during the course of this module.
TERMINOLOGY (20)	Before going into detail concerning the criteria for each of the 12 basic textural classes, let's identify some terminology necessary to understand and use the textural triangle.
SPECIFIC SURFACE (21)	<u>Specific surface</u> is the surface area of a soil particle per unit of mass.
PLASTICITY (22)	<u>Plasticity</u> is the property of a soil and water mixture that enables it to change shape repeatedly under the influence of an applied stress and to retain that shape on removal of the stress.
STICKINESS (23)	<u>Stickiness</u> is the adhesion of a soil and water mixture to other objects. It depends primarily on the amount and type of clay and water content.
PARTICLE COMPOSITION (24)	<u>Composition</u> is the material that constitutes a soils's makeup.
VISIBILITY (25)	<u>Visibility</u> is the ease with which an observer can actually see the individual soil particles. The three degrees of visibility are (1) can be seen with the naked eye, (2) can be seen with a hand lens, and (3) can be seen only with an electron microscope.

SHAPE (26)	<u>Shape</u> is the form of an individual soil particle. Terms usually used to describe the shape of a soil particle are round, irregular, and flat.
WATER ABSORPTION AND RETENTION (27)	<u>Water absorption and retention</u> is the ability of a soil to readily take on water and to retain this water. These two properties are primarily dependent on the amount and type of clay mineral present in a soil.
SAND (28)	Let's see how the three soil separates are described using these terms. Sand is the largest of the soil separates.
SAND COMPOSITION (29)	Sand is composed of parent rock materials such as granite, or of primary minerals such as quartz.
Slide of "Sand" (30)	Sand acts as individual particles.
Slide of girl running on beach (31)	They exhibit little or no plasticity and are not sticky when wet. Sand will absorb and retain low amounts of water.
Drawing of eye (32)	The individual particles are visible with the naked eye.
Slide of rounded sand grains(sketch) (33)	The particles are usually rounded or irregularly shaped and have a gritty feeling.
SILT (34)	<u>Silt</u> is smaller than sand but larger than clay. Silt particles are not visible with the naked eye, but the larger individual particles are visible with a hand lens. Silt has an intermediate specific surface relative to sand and clay.

SILT
COMPOSITION
(35)

Silt is composed mainly of primary minerals such as quartz feldspar, but may also include parent rock materials such as siltstone.

Slide of silt
showing non-sticky
behavior
(36)

Silts can exhibit some plasticity and are only slightly sticky when wet. They can absorb and retain moderate amounts of water. Silt particles are generally irregularly shaped, but are seldom flat or rounded.

CLAY
(37)

Clay is the smallest soil separate.

Slide of an
electron
microscope
(38)

Individual particles are visible only with an electron microscope.

Slide of flat
Soil Particle
(39)

The particles are flat and have large specific surfaces.

Stuck Pickup
(40)

They exhibit moderate to high plasticity and are sticky when wet.

CLAY
(41)

Clays can absorb and retain large amounts of water.

CLAY --
COMPOSITION
(42)

They are generally composed of clay minerals such as kaolinite or montmorillonite. However, some coarser clay particles may contain primary minerals such as volcanic ash.

Activity 5
(43)

Table 2, Activity 5 in your Study Guide summarizes these properties for each of the three soil separates. Activity 5 also contains definitions, explanations and illustrations of these important terms. Press the pause button to stop the tape and review this activity before continuing.

Soil Texture
Communicates the
Physical composition
of sand, silt, and clay
in a total soil sample.
(44)

Soils are rarely composed entirely of one separate.
The concept of soil texture was developed to communicate
the relative percentages of the various soil separates
in a total soil sample.

100% Clay
(45)

Press the pause button and locate the textural triangle in
Activity 4. Each side represents a single separate. Note
that the top corner of the triangle represents zero percent
silt and 100 percent clay.

100% Sand
(46)

The lower left corner represents 100 percent sand and
zero percent clay.

100% Silt
(47)

The lower righthand corner represents 100 percent silt
and zero percent sand.

USDA Textural
Triangle
(48)

Each side of the triangle is divided into ten equal parts
that represent ten percent of that particular separate.
The percentages of sand, silt, and clay are determined in
the laboratory by standardized test procedures.

Slide of Complete
USDA Textural
Triangle
(49)

You will now see how the data from such laboratory tests
are plotted on the textural triangle to correctly
classify a soil into one of the twelve basic textural
classes. These classes are divided by heavy lines on the
Triangle.

USDA Text. Triangle
with "SAND"
Highlighted
(50)

These 12 classes are:
sand,

Same except "LOAMY SAND" Highlighted (51)	loamy sand,
"SANDY LOAM" Highlighted (52)	sandy loam,
"SANDY CLAY LOAM" Highlighted (53)	sandy clay loam,
"LOAM" Highlighted (54)	loam,
"SILT LOAM" Highlighted (55)	silt loam,
Same except "SILT" highlighted (56)	silt,
SILTY CLAY LOAM" Highlighted (57)	silty clay loam,
"CLAY LOAM" Highlighted (58)	clay loam,
"SANDY CLAY" Highlighted (59)	sandy clay,
"SILTY CLAY" Highlighted (60)	silty clay,

"CLAY"
Highlighted
(61)

clay.

Activity 6
(62)

The criteria showing the percentage limits of each soil separate for each major textural class are given in Activity 6 of your Study Guide. This activity also contains the criteria for subdividing the sand, loamy sand, and sandy loam classes into "coarse", "fine", and "very fine" subgroups. Press the pause button to stop the tape and review Activity 6 at this time. Keep the textural triangle handy for reference as you study the criteria for the twelve basic classes.

Activity 7
(63)

Let's see if you understand how to determine the correct USDA textural class of some sample soils using laboratory data and the textural triangle. Complete Activity 7 in your Study Guide at this time. Press the pause button to stop the tape.

Field
Procedures
(64)

Now that you are able to determine a soil's textural classification using laboratory data and the USDA Textural Triangle, determine the textural classification of soils using field procedures.

"FEEL THE SOIL"
(65)

Field procedures used to determine the major soil textural class are primarily based on "feeling" the soil with the fingers and by observation.

CONSISTENCE
(66)

Before you make feeling tests, you must understand several terms. One of the most important is consistence.

Consistence depends on-
(1) Particle size
(2) Water content
(3) Clay Mineralogy
(4) Absence of Presence
of cementing agents
(67)

Consistence is the feel of the soil and the ease with which a lump can be crushed by the fingers. It depends upon such factors as particle size, water content, clay mineralogy, and the absence or presence of cementing agents.

Consistence offers important clues to a soil's texture.
(68)

Consistence offers clues to a soil's texture. These clues, along with experience and other properties can be used to estimate the percentages of sand, silt, and clay by weight.

Consistence for dry and wet soil
(69)

Soil scientists describe consistence at three water contents: dry, moist, and wet. Only the dry and wet descriptions are discussed in this module because they affect the results of the various field tests used to determine a soil's texture.

CONSISTENCE -
When dry
(70)

Consistence when dry is determined by breaking an air-dry clod of soil between the thumb and forefinger in the hand. It is described by the relative rigidity, brittleness, and maximum resistance to pressure. It is the ease with which the clod may be crushed into a powder or fragments. The crushed material does not cohere when pressed together. Descriptive terms commonly used to describe consistence when dry are loose, soft, slightly hard, hard, very hard, and extremely hard.

Consistence-
When wet
(71)

Consistence when wet is determined at or slightly above field capacity (water content at 1/3 atmospheres pressure) or slightly above the plastic limit.

Two properties used in describing a Soil's Consistence
(72)

Two factors, stickiness and plasticity, are evaluated in the field to describe the consistence of a soil when it is wet.

STICKINESS
(73)

Stickiness is the quality of adhesion to other objects. For field determination of stickiness, soil is pressed between thumb and forefinger, and its adherence is noted. Terms used to describe stickiness are nonsticky, slightly sticky, sticky and very sticky.

PLASTICITY
(74)

Plasticity is the property of a soil that enables it to change shape repeatedly under applied stress, and retain that shape on removal of the stress. For field determination of plasticity, roll the soil between the thumb and forefinger, or between the palms of the hands, and observe whether or not a wire or thin ribbon of soil can be formed. Terms used to describe plasticity are nonplastic, slightly plastic, plastic, and very plastic.

ACTIVITY 8
(75)

Activity 8 in your Study Guide contains a detailed discussion of consistence and the factors that must be evaluated. Press the pause button and review this activity at this time.

Additional field tests
used to determine a
soil's textural class.
(76)

Four additional field tests are made to determine a soil's textural class. The water content of the soil is the same as consistence when wet.

MOLDED BALL
(77)

Molded ball is the property that allows a soil to be shaped like a ball under applied stress and to retain its shape while forming. To determine this in the field, roll the soil in the palms to develop a ball, and observe its resistance to breakage when stress is applied by a finger. Remember, the soil should be at a water content slightly above its plastic limit.

RIBBONING
(78)

Ribboning is the property of a soil that allows a flat ribbon to develop under applied stress and to retain that shape. For field determination, press soil between thumb and forefinger until the ribbon formed breaks, then measure the ribbon. Definitions are expressed in the length of ribbon formed. They are none, 0-2.5 centimeter, 2.5 - 5, and greater than 5 centimeter.

GRITTIINESS
(79)

Grittiness is the abrasive action felt by the thumb and forefinger or palm of the hand when kneading soils. To determine the amount of sand in the field, rub the soil between the thumb and forefinger or palm of hand. A word of caution must be offered. Do not bias observations because of a few large sand grains. Acceptable terms for describing grittiness are somewhat gritty, gritty, and very gritty.

SMOOTHNESS
(80)

Smoothness is a quality exhibited by some soils when kneading between the thumb and forefinger or palm of the hand. Soils are smoothest when they contain few, if any, sand grains. For field determination rub the soil between thumb and forefinger or palm of hand. Terms used to describe smoothness are somewhat smooth, smooth, and very smooth.

Activities 8 & 9
(81)

Activities 8 and 9 in your Study Guide contains detailed explanations of consistence and other field tests used to determine a soil's textural class. Press the pause button to stop the tape and study these activities.

Activity 10
(82)

Now that you are familiar with the descriptive terms that you will need to evaluate by feeling the soil, press the pause button and locate the Flow Chart, Figure 5, Activity 10.

USE OF FLOW CHART

- (1) Start at top of chart.
 - (2) Work your way down the chart.
 - (3) First Textural class reached is the correct one.
- (83)

You must begin at the top of the chart and work your way down through each decision block until you arrive at the textural class.

REMEMBER
(84)

Remember, Table 3 of Activity 10, also contains the reactions to the various "feel" tests to assist you. Improved accuracy can be obtained with experience and practice, especially on soils with which you are familiar and for which you have laboratory data for comparison.

FACTORS AFFECTING
FIELD ESTIMATES OF
TEXTURE

- (1) Type of clay mineralogy
 - (2) Organic Matter content
 - (3) Mica content
 - (4) Salt content
 - (5) Others
- (85)

Certain factors can affect the estimates of textural classes using field procedures. Some of the more important ones are the type of clay mineralogy, organic matter content, mica content, and salt content.

Activity 11
(86)

Activity 11 in your Study Guide discusses some of these factors and tells how they can affect a soil's estimated texture. Press the pause button to stop the tape and study this activity.

Slide of all 4
Objectives with
No. 1 highlighted.
(87)

Let's review the original objectives to evaluate our progress.
Objective 1 was to list and explain the definitions of the three soil separates as used in the USDA Textural Classification System.

Same except No. 2
highlighted
(88)

Objective 2 was to correctly classify a given soil into the correct USDA Textural Class using given laboratory data and the textural triangle.

Same except
No. 3 highlighted
(89)

Objective 3 was to explain the relationship of soil consistence for dry and wet soils and their textures.

Same except
No. 4 highlighted
(90)

And Objective 4 was to correctly classify soil samples into one of the twelve USDA textural classes using the flow chart, consistence, and other field tests.

Complete Activity 12
(91)

To evaluate your competency in meeting the first three objectives, complete Activity 12 in your Study Guide. Activity 13 involves your actually working with a set of known and unknown samples. You will practice running the various field tests on the known samples and determine their textural classes and then compare your results with the correct answers. After you are familiar with the various tests and have practiced on several soils, you will be given several unknown samples to classify.

Notify your
supervisor that
you are ready for
Activity 13.
(92)

You should notify your supervisor that you are now ready for this activity. It will require 4 to 6 hours to complete and will be supervised by a designated trainer, usually an experienced soil scientist. Your supervisor will notify you of the date, time, and location of this activity. Be sure to take your Study Guide for this module with you to the training location.

Practice on soils
from your local
area.
(93)

Until the training session is held, it is suggested that you practice running the field tests on soils from your local area.

Congratulations
(94)